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PREPARATION AND TRAINING OF THE TEACHER OF CHEMISTRY.*

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A recent number of a popular educational journal contained the following significant statement: "One becomes weary of listening to the numerous descriptions of what the teacher ought to be, when teachers are and will continue to be just ordinary mortals." At a first glance this assertion seems true, but a more careful consideration leads us to conclude that it is a specious half truth. The programs of educational gatherings during in the last five years in this country and in England have had one marked characteristic, viz., an unusually large number of papers and addresses on the art of teaching. This is specially true of those meetings devoted to science. At the meeting of the American Association for the Advancement of Science held at Denver in August, 1901, seven papers on the teaching of chemistry were read before the Chemical Section, one of them being the annual address of the vice-president and chairman of that section. These papers covered all branches of pedagogic chemistry, and their presentation confirms the view that, however weary some may be of hearing what a teacher and teaching should be, all are not disposed to ignore the public presentation of this means of improvement.

* An address delivered at the Sixth Annual Conference of the New York State Science Teachers' Association held at Syracuse, N. Y., Dec. 27-28, 1901.

Progress in teaching comes largely from consultation, comparison and publication. Bad methods can never be eliminated by concealment, nor can good ones be spread by hiding them under a beaker or in a water bath. Methods need constant regeneration. Education, specially in science, is evolutionary. There are few long steps, few sudden leaps in our work. We must keep moving; the fountain must be constantly playing. Cessation is stagnation. I hope the time will never come when we can not talk, write, consult and argue about our work.

Teachers of chemistry need a broader, more uniform, and more accurate knowledge of the fundamental facts and principles of chemistry. The foundation is essential to the stability of any superstructure. If our knowledge of the fundamentals is uneven, or out of plumb, then our superstructure will be rickety and in danger of cracking or of falling over at some critical moment. Several reasons lead me to emphasize this factor in considering the preparation and training of the teacher of chemistry.

At the last meeting of the Johns Hopkins University Alumni Association of New England a classmate, who is connected with a large college, said, "The weakest part of our course in chemistry is the general inorganic for beginners." This is true, no doubt, of many other colleges. Several unfavorable conditions attend the instruction of beginners in chemistry in college. The laboratory sections are often too large to permit individual instruction, the text is usually presented to indifferent listeners in the form of entertaining lectures or of an intricate outline, and the course itself is often condensed to ridiculous brevity in order to conform to the unavoidable restrictions of the curriculum. It is true that these conditions are sometimes unavoidable and that the department of chemistry is only partly responsible for them. Nevertheless, the students suffer, and too many graduate from college inadequately prepared to teach elementary chemistry, because their instruction in that portion of the subject has been irregular. It is as true of chemistry as of most subjects, that we know best what we studied last. And many a recent graduate attempts to force his latest work on suffering and helpless beginners. President Remsen once said that when he left

the University of Tübingen he could teach the most advanced organic chemistry better than the elementary inorganic chemistry. In many colleges the student passes directly from general chemistry to qualitative analysis, then to quantitative analysis, and finally to organic chemistry or some other advanced work. Seldom does he have a chance to review his general chemistry from a broad standpoint. There is a tendency in some institutions to remedy these defects, and before many years students while in college will be able to lay those broad foundations which are so essential for effective teaching of elementary chemistry.

A second reason for emphasizing the necessity of a better knowledge of the fundamentals is that in the last five years such an enormous number of facts has been literally hurled at us that those houses which are built on the sand are in danger of being swept away. Physical chemistry, electro-chemistry, chemical inactivity at low temperatures, dissociation at high tempera-

atter inert at all temperatures, radiant energy, molecules of eight atoms, molecules of a single atom, and liquefied gases galore have been suddenly thrust on us. I am not a foe to these newer conceptions, nor am I indifferent to the magnificent results obtained by such men as Ramsay, Nernst, J. J. Thomson, van't Hoff and others. But important as these topics are and will become, they should not be allowed to usurp or obscure our conception of the foundations of chemistry. A teacher in a large high school was asked by the writer what use he made of the theory of electrolytic dissociation. He replied, "I did considerable with it last year, but this year I shall do very little because my pupils did not see so much in it as their teacher did." Doubtless a similar vision of the situation led one of the best known teachers of chemistry in this country to say in the preface of his latest book, "In the opinion of the author the time has not yet come for the abandonment of the study of the elements and their compounds in what some are pleased to call the old-fashioned way. Indeed it seems essential that such study must always form the basis of the higher or spiritual study of chemistry." In a few years, no doubt, many of the simpler aspects of physical chemistry will form a part of our elementary courses in chemistry and must therefore be assimilated by teachers, but since physical

chemistry is now only a part of the superstructure, it should not be mistaken for the whole edifice. Only the teacher who has a broad knowledge of fundamentals can appreciate the meaning of new details, for such a one alone can determine the value of component parts of the whole. Comfortable teaching is based on an accurate knowledge of the first principles, it rests on unshaken confidence in the primary truths. The teacher who lays the foundations wide and deep need never fear overthrow. On them he can build with assurance as high and attractive a superstructure as desired. A teacher runs no risk of being left behind in taking a year or more to strengthen the foundations. He can easily catch up with the facts, and as he moves onward these facts will find a logical and permanent location in his mind.

A convenient and efficient way to obtain a knowledge of the underlying facts and principles of chemistry is by a judicious and thoughtful study of one of the large manuals of chemistry, such as Remsen's, Mendelieff's, or Freer's, Newth's, Richter's, or Roscoe and Schorlemmer's. Working familiarity with any of these books is an enviable acquisition. They are reservoirs from which we may draw our supply at any time. Make a business of it. Take a year for the task, if necessary. Read with a notebook at hand, or better still mark the margin of the book itself. Determine to remember where and how the facts and principles are treated. Imbibe the spirit of the author, see the truth from his standpoint. Do not be satisfied till the task becomes a pleasure. Gradually the whole panorama will come into view, facts hitherto unknown will assume their proper relation to the whole subject, experiments which one may have thought were his own discoveries will be accredited to the rightful discoverer (possibly Boyle or Lavoisier), laws will reduce themselves to that beautiful simplicity which is an expression of an harmonious nature, theories instead of being mere guesses will inspire to deeper thought and perhaps to intelligent experiment, and out of the vast mass of facts, laws, hypotheses, and theories a foundation will unconsciously be laid on which can be built with confidence and skill a superstructure in which ideas new and old may be harmoniously, artistically, and truthfully incorporated.

The preparation and training of the teacher of chemistry

should not be confined solely to this science. Interest should be stimulated in allied sciences. No single science is an independent unit; all overlap. Chemistry has some connection with all the physical and life sciences. Together with physics and pure mathematics it forms the great triangular foundation of physical science. Hence a general knowledge of other sciences is not only helpful but to a certain degree necessary to the successful teaching of chemistry. Such a knowledge keeps one from becoming warped and prejudiced in his judgment of the methods, value, and significance of other subjects in the curriculum. Love and enthusiasm for chemistry should not mean contempt and hatred for physics or biology. In answer to the question, "Do you prefer to teach another science besides chemistry?" 19 out of 20 representative teachers in Massachusetts replied "Yes." Those who taught physics invariably regarded this additional work as helpful. The speaker has found physics and mineralogy exceedingly helpful in interpreting many phases of general inorganic chemistry. A science needs a margin, a sinking fund, a reservoir, just as a picture needs atmosphere or a poem needs inspiration. A knowledge of perspective alone will not make an artist, nor will a knowledge of prosody make a poet. And it is just as true that a knowledge of chemistry alone will not make a good teacher of that science. We need "the more" to apply "the little," something beyond the subject to teach subject-matter. Our point of view, our estimation of values, our humor, our judgment, our mental horizon, our general reading, and our hints for the pupil's reading, all these really depend on something outside of mere chemistry. Photography, astronomy, mineralogy, geology, and physical geography stimulate interest in certain aspects of chemistry. This margin, this finish, this better part is that indefinable something which places the inspiring teacher on the right hand and the dull pedagogue on the left.

Probably most teachers of chemistry have at one time or another studied other sciences. It is advisable to arouse this dormant interest and to acquire a generous sympathy, a working knowledge of these sciences. This may be done by reading the scientific journals, such as *Science, Scientific American, Popular Science Monthly, American Journal of Science, Journal of the*

Franklin Institute, and by all means the latest journal, SCHOOL SCIENCE. Avoid newspaper science. It is usually downright absurdity or barefaced error. A few hours' judicious reading during a month will suffice to keep pace with all that one need know of other sciences. Form the habit of reading these journals and stick to it. A German professor was once asked about the progress of a former student. He shook his head and replied, *"Ach, er liest nicht mehr"* (Alas, he reads no more). Let us take care that we are not similarly condemned.

A few years ago the New England Association of Chemistry Teachers sent out a list of questions, mainly to New England teachers, covering all phases of teaching. Among the questions was this one, "What is your aim as a teacher of chemistry?" An answer which typifies the aim of the best teacher was, "To teach pupils a love for truth and for the science, and to develop a scientific spirit." A most desirable requisite which teachers themselves need is a scientific spirit, or, perhaps better, a scientific attitude of mind. The distinguishing feature of science teaching is not merely the provision of an opportunity to observe, conclude and record. Its vital object is to create and foster a scientific attitude of mind. The highest attainable result will follow, if a scientific spirit is aroused.

That attitude of mind called scientific is hard to describe. One of the most scientific teachers of chemistry in the United States said, "It is asking a great many questions, but few foolish ones." Some of its attributes are a determination to know all the evidence before pronouncing a judgment, precision in thought and statement, a desire to deal with the thing itself, not trusting to secondary sources, unshaken confidence in the triumph of truth, fearless abiding by tested results, willingness to change our conclusions when new evidence is presented, disbelief in the traditional superstitions and nonsense of our ancestors.

Sometimes contrast makes a subject clearer, and possibly the term scientific may be made clearer by illustrating an unscientific state of mind. To deny the truth of what displeases us is unscientific. It is also unscientific not to admit our errors, specially our published errors. It is likewise unscientific to accept

elastic theories. Prout's hypothesis, the evolution of the elements from a single element, and theories which violate the laws of thermodynamics belong to this class. It is furthermore unscientific to jump at conclusions which we would like very much to draw, if we only had sufficient evidence. How many new elements are annually announced! How many new discoveries are daily heralded which will set the earth spinning from the east to the west as soon as the pseudo-discoverer has obtained a little more evidence! We need more chemists like Morley and no more physicists like Tesla, we need more astronomers like the late lamented Keeler and no more like—well, I must not be captious. I am sure the point is clear.

Probably no general rule can be prescribed for the attainment of a scientific attitude of mind. Yet it can be cultivated. One of the best ways to acquire and foster it is to do some original work. It matters not how extensive or how slight the work, provided it possess the element of originality. Nature by some inscrutable law has decreed that we can learn only of and through ourselves, no one else can learn for us. The soul itself must come to a consciousness of the truth before knowledge is a possession. Every bit of original work coins knowledge. An original demonstration of the hitherto unknown properties of a chemical compound is worth more to the experimenter than a vast mass of memorized facts. The construction of a new piece of apparatus or the improvement of a method demands continuous exactness of thought infinitely more helpful in acquiring a scientific attitude of mind than can be gained by the remodeling of the whole scheme of qualitative analysis. One reason, I fear, why some teachers shrink from the performance of a few simple experiments demanding exact weighing or measuring is their inability—or would I not better say unwillingness—to carry out the train of reasoning involved in such work. A few hours a week—part of our wasted time—spent in the performance of some original work will soon give that attitude toward teaching science which a judge has in the trial of cases. It will give a mental grasp which is comprehensive enough to perceive the exact value of evidence. It will bring one face to face with truth.

It is imposible, however, for all teachers of chemistry in secondary schools to do research work. Numerous duties consume all spare time, apparatus and materials are not readily obtainable, and books and chemical literature are not always available. On the other hand, it is possible for such teachers to do some work possessing the element of originality. The simplification of apparatus, the wider application of new methods, the qualitative examination of some mineral, rock, mineral water, or industrial by-product offer ample opportunity for original work. Again, if no such work can be done, the teacher should write. Exactness of statement is a mark of exactness of thought. And exactness of thought may be acquired by critical writing. Put your thoughts into accurate language. Tell us about some interesting natural phenomenon in your locality, an example of chemical erosion, a piece of apparatus which has helped you over a hard place, write a brief biography of some of the living chemists, tell us about anything which interests you. What interests you will surely interest someone else. A managing editor of *The Sun* (New York), when asked by a correspondent what to write up, replied, "Anything that interests you—nothing else." Stevenson always carried two books in his pocket, "one to read in and one to write in." Publish what you write, read it before some association or to a friend. Help overcome the false notion that a scientist can not write clearly and entertainingly. Help make it impossible or at least untruthful for an editor to announce in a prospectus, "We assure you that these articles on science will be both good writing and good science, a combination that is unfortunately too often lacking."

Till about a decade ago chemistry was taught in high schools almost exclusively by a textbook. The pupil studied the book, recited what he had time to memorize, and occasionally listened to lectures or talks by teachers who often did some experiments. This unscientific method of teaching the science of chemistry began to be abandoned about ten years ago. Some schools went to the other extreme in allowing the pupils to do all the experiments, while the teacher did the studying and reciting. Fortunately the evil effects of this second unscientific method of

teaching the science of chemistry were soon discovered, and it is gradually being replaced by a judicious combination of individual experimental work done by the pupil, study, explanation, and recitation of textbook by the pupil, and informal lecture instruction by the teacher. It would be profitable to discuss the bearing of these three elements on the preparation and training of the teacher of chemistry, but the discussion will be limited to one phase of one element, viz., the supervision of laboratory work.

It seldom happens that a method of teaching changes suddenly, but when the change is abrupt, the application of the new method is attended with more or less misfortune. The laboratory method of teaching chemistry came on us rather suddenly, and in many schools its use has not only been injudicious but unprofitable. We know very little about its psychology and still less about its ethics. Many teachers can not account for their failures, and hence they are not slow to condemn the laboratory method, whereas it is the fault of the teacher, not of the method. Though my views on this question have appeared in print, I can not refrain from repeating some of them, because I believe the failure to grasp certain psychologic principles accounts for much of the aimless work done by pupils and for some of the unrest, discomfort, and inefficiency shown by many teachers in all sections of the country.

Laboratory work is concrete labor. It employs the hands as well as the head. Concrete labor is difficult to shirk. In studying history, geometry, or language the mind easily wanders. But when the mind is following an experiment in the laboratory, it does not readily ramble. Something is constantly happening; the mind being carried quickly from concrete to concrete has little or no time to roam. Apparatus must be arranged, chemicals collected, the experiments started, watched, controlled, or stopped. If, however, the teacher or the principal does not favor laboratory work, if the program restricts the experimental work to a pitiable minimum, if the teacher persists in explaining in the classroom what the pupil can think out unaided in the laboratory from his own data, then it is folly to expect the laboratory work to yield mental results. There must

be enough carefully prepared and judiciously supervised laboratory work to prevent the normal tendency to shirk, as well as to teach the pupil the supreme value of mental self-reliance. Again the experimental work must be dignified enough to command the self-respect of a thoughtful pupil but not so difficult or repulsive as to frighten him, for in either case the tendency to shirk will be hard to overcome. Furthermore, the laboratory work must be followed up by searching questions, for if the pupil once gets the idea that he need not think after he has completed his experiment, then you have opened for him a broad avenue for shirking. Each pupil should be taught at the earliest possible moment that he or she may be asked any reasonable question on any experiment. If such a spirit prevails, pupils soon learn to get from this concrete labor that invaluable acquisition, so often needed in later life, viz., the power to complete a piece of work accurately, quietly, quickly.

Again laboratory work is suited to relieve mental fatigue. It is restful work, if rightfully performed, because it affords opportunities for harmonious activity. But, if the laboratory period is too long or too short, if confusion reigns, if there is no opportunity for pupils, especially girls, to sit down in the laboratory while writing notes, consulting reference books, or performing slow experiments, if the directions for performing the experiments are brief, long, or so vague that their interpretation demands an excessive amount of mental energy, then mental fatigue will be increased, not relieved. The laboratory work under such circumstances can not afford that mental rest which it is designed to provide. Mind and body will refuse to act normally.

Third, laboratory work is a grand medium for the production of the highest grade of reactive conduct. Reception is followed by reaction, impression by expression. Motor activities are the expression of thought. But, if the laboratory work is inadequately supervised, owing to large divisions, program irregularities, or pedagogic inefficiency, then the reactive conduct will be of a low, perhaps the lowest, grade. The pupil who is called on to be doing something constantly should be stimulated by an environment which will enable him to do the right thing in

the best way. Good expression can not come from bad or meager impression. Teachers of chemistry who let the laboratory run itself, who do not help a confused pupil to regain mental poise, who do not realize that beginners need constant advice and direction, are unprofitable servants of the science of chemistry. The teacher's place is beside the pupil, showing him how to form good habits of observation, teaching him the difference between accuracy and vagueness, preventing him from doing slipshod or slovenly work, stimulating him to cultivate mental self-reliance, not telling him facts which he can observe himself, but suggesting legitimate channels for the application of his total power. I recall with pleasure my work under President Remsen, because he never discouraged me when I needed help and he always left me to myself when he saw that the best avenue to escape was through my own mental efforts.

Again, we must not be satisfied because our pupils are curious. Curiosity is a good sign, but at best it is only a means to an end. It should be encouraged at first, but, once active, it should be rationalized. Pupils must be led from curiosity to interest, from mere indiscriminate desire to know disconnected facts to an intelligent craving for systematic knowledge. The transition from curiosity to interest is a critical time for both teacher and pupil. Too often a thoughtless word, an unintentional oversight, or a palpable lack of interest on the teacher's part may upset the delicate poise of the pupil's mind and turn to permanent indifference or reckless curiosity what might have become lifelong interest. Special care should be taken by the teacher to gather up the disconnected observations made by pupils and place them before the learner in such a light that the threads of curiosity will become the fabric of interest. Once interested, the pupil should be led on into the realm of voluntary attention. It is this factor that we all need to develop, for it is of incalculable value in the acquisition of knowledge; it is essential to complete psychic life.

Pupils seldom see the importance of voluntary attention. They are contented to "do experiments" and stop there. They need to be taught the fundamental value of learning to complete with success an experiment requiring patience, skill and confi-

dence. The necessity of teaching voluntary attention is one reason why I believe so firmly that simple quantitative experiments should form a definite part of an elementary course in chemistry. Such work cultivates voluntary attention. As I have watched my classes for several years perform simple experiments involving accurate weighing or measuring, I have been forced to conclude that this work is the most effective way of teaching voluntary attention. It requires an effort of the will for spirited pupils to sit quietly before a balance till the pans stop swinging, to wait for a solution to run down the inside of a burette before the volume is read, to let a thermometer remain in a liquid long enough to assume the temperature of the liquid. But this very effort of the will is needed day after day when the pupil leaves school. It must be acquired, if one is to be a successful worker in any field.

Whatever or wherever our occupation, we shall always need the power to think continuously, work skilfully, and judge accurately. We do not need chemists half so much as we need men who will voluntarily attend to their work. The problems which are coming on us as a nation need for their solution men who have been trained to do things accurately, with dispatch, with a regard for all the evidence, with a profound love for truth, for that truth which is so forcefully exhibited by the laws of chemistry, for that outer truth which arouses in one a consciousness of inward truth.

Closely related to curiosity, interest, and attention is the principle of inhibition. It was thought about half a century ago that certain nerves checked the action of certain muscles. This is doubtless true, but it is a narrow interpretation of a more general function of the nervous system. This conception of arrest has been extended to cover our mental life, irrespective of nerve stimulus as such, and is called inhibition. It is not necessary that an inhibiting idea be specially strong to arrest another idea, for here as elsewhere the mental machinery is delicately adjusted. A strong motor idea may be easily and completely inhibited by a simple and apparently foreign idea. Faint impressions on the confines of consciousness may throw a strong idea completely off the track. Some trivial observa-

tion may upset a thought which is seeking expression, and either arrest it completely or so modify it that the final judgment is delayed or even completely abandoned. Pupils should not be allowed to yield to unwarranted inhibitions. Provision should be made in all laboratory work for allowing the pupil's mind to travel without needless inhibitions from the object of the experiment through the manipulation to the conclusion. The work should be so supervised that pupils will see the whole field of consciousness and not yield to reckless impulse or foolish inhibition. Many books now in use actually prevent the mind from acting calmly, continuously, and logically. Experiments to be mentally profitable should be so expressed and arranged that the average pupil can not fail to grasp the title, the exact method of procedure, the essential observations to be made, and the probable conclusion which the observations will permit. The title of each experiment should be known so that the pupil may have an initial idea, a mental start, a guiding star. Unless he begins correctly, he may not, probably will not, end correctly. A knowledge of the exact method of procedure is essential, otherwise he will not know how, when or where to begin his work, nor can he carry it on intelligently, confidently, profitably. A great deal of time is wasted in a laboratory because pupils do not know how to work, and in many cases they are not to blame for this aimless, fruitless labor, because they were not at some time told or shown how to work. They yield to some foolish inhibition or reckless impulse, simply because they see no other path. Again, the desired observations should be indicated in some way. Pupils are learning how to observe; one object of experimental work is to teach observation. Surely we ought not to assume what we are trying to teach. Beginners do not know the difference between the trivial and the important, the scientific and the unscientific. They must be pointed toward the path having the fewest inhibitions, even though such direction reveals some truth which they might possibly discover if sufficient time were taken. Finally, each experiment should lead to some definite result. Otherwise the student is left suspended, is actually robbed of the inestimable privilege of drawing a conclusion. Experience shows, however, that this conclusion must

be indicated. It need not be deliberately told, but it can be suggested by appropriate questions. Such questions eliminate inhibitions, they conduct the mind along a logical path, they extend a helping hand to a halting thought, they train the mind to pass from cause to effect.

If you ask how the teacher may attain the power to apply these principles, the answer is simple. Study your pupils and yourself, but yourself the more. The problem has only two unknown quantities—yourself and your pupils. Success depends on the teacher's knowledge of his own psychologic and spiritual life as well as on the discovery of mental crises in his pupils. He must create an atmosphere which fosters calm, deliberate, confident, tranquil mental action. He himself must have passed through the gates of curiosity and interest into the temple of voluntary attention before he can lead others to the same spot. He must acquire that spiritual insight which perceives the truth in himself, he must be constantly conscious of that better self, for it is this unseen self which teaches.

HIGH SCHOOL BOTANY.

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(*Concluded from page 438.*)

In all subjects we aim first at a mastery of the broad general facts, in order that we may get a perspective of the subject as a whole, and then, if it is pursued further, we study into the details. After the subject has been mastered in its broad general outlines a study of minute details can be taken up with profit, and not before. This study of details is the work of the specialist, is the work that the college aims to do, but which can be pursued with profit only after the student has mastered the broad general facts in schools below the college. Says L. H. Bailey, "The youth is by nature a generalist. He should not be forced to be a specialist." If we

attempt to do exact and technical work in the high school we are trying to reverse the order of the child's development, which must of necessity result in arrested development.

If there had been a well regulated course in nature study in the grades leading up to botany in the high school, then there might be some excuse for such a treatment of the subject, but in most schools, at the present time, no such course is given although it is offered in most cases. The only way to make botany in the high school a study worthy a place on the program is to make it a continuation of nature study in the grades, and not a scientific study of college botany which can have no interest or benefit to the pupil, because he has nothing upon which to build such a study. Even though we have a well regulated course in nature study in the grades, some of the botany that is being taught is too difficult for pupils of high school age. It is a misfit.

In my opinion, the child should be brought in contact with the plants about him. He should make a study of them, not a scientific study however, year after year from the first grade to the ninth, when he will be prepared to take up high school botany. This acquaintance ought not to be a hit and miss acquaintance, nor an attempt to become acquainted with all plants about him, but more particularly with those which have some human interest because they have in some way or another contributed to man's enjoyment or benefit, or because if harmful a knowledge of them becomes beneficial. Botany should be replete with human interests. It should be paved with common associations.

He should be taught to become acquainted with plants as living things, having a life cycle, and which may be benefited or harmed according to treatment. He should be taught to have a wholesome respect and even reverence for plants, such that may react upon his ethical and spiritual nature and thus become a potent factor in character building, before he begins the scientific study in a laboratory which treats plants more or less as inanimate objects. If this exact study is begun before the child has become acquainted with plants in their homes, and before he has become conscious of "an unseen power, of life in life and life behind life, of God, and of coöperation with the unseen life," it is quite apt to play no part in developing his ethical and spiritual nature, or, what

is more, he may even lose what feeling he may perchance have cultivated for nature. If the study of botany serves no other purpose than that of leading the pupil to higher ideals it will have a just excuse for a place in every course of study, but if the present method of study militates against this, as I believe it does in most cases, then it would be far better if the subject were left out entirely, and the child's only knowledge of botany remain that of chance acquaintance with plants which he may look upon as friends rather than the dry, lifeless and uninteresting things which he was forced to study in school, and which he remembers only with a pang. The little knowledge and discipline that is obtained under existing conditions is not worth the sacrifice.

The high school course in botany should be a continuation of nature study in the grades, whatever that may be. If there has been no nature study in the grades, then the child should begin at the beginning, using only the knowledge of plants he has perchance acquired as a foundation. Wherever or whenever he begins this study his acquaintance must grow ever wider and deeper, and with the life element always a prominent factor. Never, however, at any stage, should he go deeper into the study than at that particular time his stage of development will permit.

No doubt the present method of teaching botany trains the observation to some extent, disciplines the mind, and imparts some knowledge, the greater part of which is valueless to the average high school graduate. Botany should do more than this if it is to claim a place on the program to-day when there is so much to teach that is worth while. It should have an ethical value, and should impart useful knowledge about plants which have a human interest.

I believe that the kind or quality of botanical knowledge that is being taught is wrong for the high school. The knowledge should be useful knowledge. The course should offer something which would make the pupil feel that it is worth while to know, something that is necessary to fit him for life, rather than something that is to fit him for college. That which best fits the pupil for life ought to best fit him for college, otherwise the college had better get closer in touch with the human element in education. "Life is real, life is earnest," and it ought not to be marred by dull, lifeless, and meaningless exercises in botany which can have

no other result than that of dulling the senses and feelings, and occupying time which could be better spent.

To give useful knowledge of plants may not always follow the "scientific" treatment of the subject, yet, in my opinion, useful knowledge ought not to be sacrificed in order to follow out some "scientific" treatment. There is so much of botany that has a direct human value, that it seems an utter waste of time to study out problems for the sake of the problems, or to study out the parts of plants and their minute structure which are wholly unrelated to man's needs. If a course in botany could be worked out along the lines I have indicated I think much of the criticism we now hear about botany would be removed.

Botany when taken up in this way will furnish the maximum development of mental power and character. The mind will always be coping with problems within its range, and the feelings will be stimulated rather than blunted. There are numberless problems to be solved which are at the same time useful and disciplinary. The powers of observation, too, will be developed as they never can when the pupil is confined to a study of details in a magnificent and over-equipped laboratory. The subject will be made a live subject, dealing with things of life. It will be made real and fascinating. Pupils will take to it because it is within their mental range, and because it is a study of the most important gift of Nature to man—the plant. A subject which deals with objects of such great importance to man ought not to be barren of results if taken up in the right way. That it has been so unprofitable a study, I take it, is largely because we have been dealing with the wrong phase of the subject. The quality of knowledge has been wrong.

It would seem to me, that it goes without saying that botany work in the high school which gives a broad general view of the subject, which acquaints the pupils with plants as living, growing and useful, ought to be the best preparation for the pupil who goes directly from the high school into life's work, and also the best preparation for the special work which the college aims to do. The high school must fit the pupil for life first, and if this preparation at the same time fits him for college, so much the better. It seems that botany, when rightly treated, ought to do both at the same time.

THE TRAINING AND WORK OF A GEOLOGIST.

BY C. R. VAN HISE.

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Geology is a dynamic science, subject to the laws of energy. Geology treats of a world alive, instead of, as commonly supposed, a world finished and dead. The atmosphere, or sphere of air, is ever unquiet; the hydrosphere, or sphere of water, is less active, but still very mobile; the lithosphere, or sphere of rock, has everywhere continuous although slow motions. The motions of the atmosphere, the hydrosphere, and the lithosphere alike include body motions by which the positions of large masses of material are changed, and interior motions, through which the mineral particles are constantly rearranged with reference one to another, and indeed are constantly remade.

No science is independent of other sciences, but geology is peculiar in that it is based upon so many other sciences. Astronomy is built upon mathematics and physics. Chemistry and physics to a considerable degree are built upon each other. Physics also requires mathematics. Biology demands a limited knowledge of physics and chemistry. However, it cannot be said that a knowledge of the basal principles of more than one, or at the most two, other sciences is an absolute prerequisite for a successful pursuit of astronomy, chemistry, physics or biology. This is not true of geology. In order to go far in general geology one must have a fair knowledge of physics, chemistry, mineralogy and biology. These may be called the basal sciences of geology. In certain lines of geology the additional sciences, mathematics, astronomy and metallurgy, are very desirable.

Geology treats of the world. In order to have more than a superficial knowledge of geology, it is necessary to know about

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Vice-presidential address, Section E, Geology and Geography, American Association for the Advancement of Science, Pittsburg meeting, 1902. The extracts of the address here given seem as applicable to the student in the secondary school and as helpful to his teacher as to the more advanced students to whom it was addressed.

the elements which compose the world; how force acts upon these elements; what aggregates are formed by the elements and forces, and how life has modified the construction of the world. Chemistry teaches of matter; how it is made up, both in life and in death. Without an understanding of its principles we cannot have an insight into the constitution of the earth or of any part of it. Physics teaches of the manner in which the many forms of that strange something we call force acts upon matter. Without a knowledge of its principles we can never understand the transformation through which the world has gone. The elements which compose the earth under the laws of physics and chemistry aggregate into those almost lifelike bodies which we call minerals. The minerals are commingled in various ways in the rocks. Without a knowledge of mineralogy no one can have even a superficial understanding of the constitution of rock masses. Biology teaches of the substances alive which clothe the outer part of the earth. Life is one of the most fundamental of the factors controlling the geological transformations in the surficial belt of weathering; it has acted as the greatest precipitating agent in the sea. Life has had, therefore, a profound and far-reaching effect in determining the nature of the sedimentary formations.

The sciences of chemistry, physics and biology have been built up by using minute parts of the materials of the earth. If geology, or a science of the earth, is to be constructed, it must apply to the earth as a whole the principles which have so enlightened us as to the nature and relations of the fractions of the earth, which we observe and handle in our laboratories of physics and chemistry and biology.

It thus appears that geology is a composite science; and it might in a certain sense be called an applied science. Indeed I have often defined geology as the application of the principles of astronomy and physics and chemistry and mineralogy and biology to the earth.

Certainly the earth is the single enormous complex aggregate of matter directly within the reach of man. This highly composite earth is the joint result of the work of astronomical,

physical, chemical and biological forces; working on an incomparably vaster scale than can ever be imitated in our laboratories. A study of these mighty results has already advanced at many points astronomy, physics, chemistry and biology, and future studies made with direct reference to the causes which have produced the earth are sure to lead to even greater advances in these studies.

If geology is to become a genetic science, or, more simply, is to become a science under the laws of energy, geology in large measure must become a quantitative science.

If I have correctly stated the relations of geology to the other sciences, it follows as a corollary that those only can greatly advance the principles of geology who have a working knowledge of two or more of the sciences upon which it is based.

By a working knowledge of a science I mean such a knowledge of its principles as makes them living truths. One must not only be able to comprehend the principles, but he must see them in relation to one another; must be able to apply them. It is not sufficient for a carpenter to be able to explain how the hammer and saw and plane and chisel work; he must be able to use them. He must be able to hit the nail on the head; to cut straight; to plane smooth; to chisel true; and do all upon the same piece of timber so as to adapt it to a definite purpose in a building. Just so the geologist must be able to apply as tools the various principles of physics and chemistry and biology and mineralogy to the piece of geology upon which he is engaged; and thus shape his piece to its place in the great structure of geological science. This is what is meant by a working knowledge of the sciences basal to geology.

It is not supposed that any one man has a comprehensive knowledge of all the basal sciences, or even a working knowledge of their principles; but such knowledge he must have of two or more of them if he hopes to advance the principles of geology. He will be able to handle those branches of his subject with which he deals in proportion as he has a working knowledge of the basal sciences upon which his special branch is based, and will probably correlate this branch with the other branches

of the great subject of geology in proportion as his working knowledge of the basal sciences is extensive.

For instance, to advance geological paleontology one must have a working knowledge of the principles of biology and of stratigraphy. To advance any of the lines of physical geology one must have a working knowledge of the principles of physics, and especially of elementary mechanics. To advance physiography one must have a working knowledge of physics and chemistry. To advance knowledge of the early history of the earth, one must have not only a working knowledge of physics and chemistry, but of astronomy. To advance petrology one must have a working knowledge of physics, chemistry and mineralogy. To advance the theory of ore deposition or metamorphism, one must know not only the principles of physical geology, with all that implies, but he must have a working knowledge of chemistry, physics, mineralogy and petrology. It is unnecessary to add that a geologist must be able to read some of the modern languages, and be able to express himself clearly and logically in one language.

Geology starts as an easy observational study, and gradually becomes more and more complex until it taxes the master mind to the utmost.

But too often men who have entered upon geological work have received no adequate training in chemistry, in physics, in biology; and therefore at the outset wholly lack the tools to successfully interpret the phenomena which they observe. But such inadequately trained men feel that a satisfactory explanation of any phenomenon must involve a statement of the underlying chemical or physical or biological principles. In such cases it is safe to say that the explanations given are extremely partial, including only a modicum of truth, and more often than not are absolutely fallacious. Indeed, no other result can be expected from one who lacks a working knowledge of the principles of physics, chemistry and biology. Occasionally there is a clear-sighted, capable man, lacking in adequate training, who does important geological work simply because he knows his limitations, and there stops. But this is very exceptional indeed;

and the physical explanations offered by many for various geological phenomena are no less than grotesque.

It has been made plain that a working knowledge of the sciences basal to geology is necessary in order to advance its principles. But I go even further, and hold that such basal knowledge is absolutely necessary in order to do even the best *descriptive* work. Good descriptive work is discriminative. Good descriptive work picks out certain of the facts as of great value; others of subordinate value; and others of no value for the purposes under consideration. How then can this discrimination be made? How can the facts be selected which are of service? Only by an insight into the causes which may have produced the phenomena. Without this insight to some extent at least a description is absolutely valueless. So far as the geologist has such insight, his description is valuable.

If my statement thus far be true, the outline of the training of a man hoping to become a professional geologist is clear. Such a man should be sent to thorough and long courses in each of the subjects of astronomy, physics, chemistry, mineralogy and biology. This means that a large part of the training of a geologist is the study of the sciences upon which geology is founded. If a man who hopes to be a geologist is wholly lacking in a knowledge of any of the basal sciences, this defect he can probably never make good. Even if he so desires, the time cannot be found. Moreover, chemistry, physics, mineralogy and biology are laboratory sciences and can be satisfactorily handled only in the laboratory. If the fundamental work in the basal subjects has been done in the college or university, one may keep abreast of their progress during later years; but in order to do this, the basal principles must have become living truths to him while a student.

In recent years it has been a mooted question in colleges and universities as to when specialization should begin, rather implying that when specialization begins broadening studies should cease. And, indeed, it is upon this hypothesis that most of the discussion upon this subject has been carried on. Some have held that specialization should not begin until late in the college course, or even rather late in a post-graduate course.

Others have held that one should early direct his studies to special subjects which he expects to pursue, and give comparatively little time to other subjects. The argument for this latter course is that competition is now keen; and if a man keeps in the race he must begin to specialize early. It appears to me that both of these answers are inadequate. My answer to the question is that specialization should begin early, but that broadening studies should not be discontinued. This rule should obtain not only through the undergraduate course, but in the postgraduate work and during professional life. The specialized work will be better done because of the broad grasp given by the other subjects. The broadening studies will be better interpreted because of the deep insight and knowledge of a certain narrow field. Thus each will help the other. No man may hope for the highest success who does not continue special studies and broadening studies to the end of his career.

But is it held that a geologist lacking an adequate working knowledge of basal studies cannot perform useful service? No, the domain of geology is so great, the portion of earth not geologically mapped and the structure worked out is so vast, the ore and other valuable deposits which have received no study are so numerous, that there is an immense field for the application of well-established principles. In geology, as in engineering and other applied sciences, there is an opportunity for many honest, faithful men to perform useful service to the world even if their early training and capacity are not all that could be desired. But even the application of old principles to new areas will be well done in proportion as the geologist has training in the basal sciences; and to the man who combines with such training talent must necessarily be left the advancement of the philosophy of geology. The philosophy of geology, the inner meaning of phenomena, was the paramount consideration to Hutton and Lyell and Darwin. To them facts were useful mainly that they might see common factors, the great principles which underlie them, or, in other words, generalization. To correctly generalize in geology involves the capacity to hold a vast number of facts in the mind at the same time; to see them in their length and breadth and thickness; to see them at the same time

as large masses and as composed of parts, even to the constituent mineral particles and the elements; to see the principles of physics and chemistry and mineralogy and biology interlacing through them. Only by holding a multitude of facts and principles in one's mind at the same time can they be reduced to order under general laws.

Failure thus to hold in one's mind a large number of facts and principles leads to lack of consistency. Often in a single book or a single chapter, on the same page, or even in the same paragraph or sentence, are contained ideas which are exclusive of one another. They are not seen by the writer to be exclusive of one another because he is so lacking in a command of the principles of the basal sciences that he is not aware of the antagonism. But the man who sees the phenomena and principles of geology in all their complex relations, and tries to express the parts of them he is considering in proportion to one another, and to place his fragment of the science of geology in proper relations to other departments of geology and other natural sciences, has a task before him requiring great mental effort. He must see and understand in three dimensions. At every point he must see the lines of cause and effect radiate and converge upon the phenomena he is considering from many other phenomena and principles. Of course all fail to do this completely in reference to any complex problem. But in so far as success would be attained, the effort must be made. In proportion as one can hold many facts and principles and see their interrelations, he will be able to advance the philosophy of geology. This is the work which burns the brain.

And his results he must express in language, the chief means of communicating ideas and relations. Yet language is linear. By figures, models, maps and illustrations, wisely used, one may to an important degree supply the defects of linear language. Yet language and illustration, even where used to the best advantage, but poorly convey one's ideas. Most conscientious writers require as much or more time to put a complex subject into words and illustrations ready for publication as they do in working out the results.

But upon the other side, and in favor of expression in lan-

guage, it should be remembered that there is action and reaction between one's ideas and the attempt to express them in words and illustrations. The necessity for expression in language is often a wonderful clarifier of ideas. The ideas are improved by the attempt at expression, and the expression is continually improved as the ideas are enlarged.

As I have already intimated, I hold that for the best liberal education one must pursue broadening studies from the first to the last, and also that one must early begin to specialize. If this be true, geology may be said to be a very desirable part of a liberal education; for it is built upon the whole realm of pure science; *i. e.,* the knowledge, which applies not only to the earth and all it holds, including man, but to the universe as well. Because of the breadth of training combined with specialization required of a geologist, it might be shown that geology is one of the most useful studies in giving a person a sense of proportion, ideas as to relative values, of perspective, qualities of the first order in this world. It might be held that the intellectual training of the geologist is of a kind which helps him in dealing with men and things; and, therefore, for handling the world's work. But time does not suffice to develop this part of the subject.

I shall now suppose that a geologist is adequately trained, that he has some power in generalization, and consider what should be his method of work. It is assumed that the young geologist spends a part of each year in the field. This field work should include areal mapping with structural and genetic interpretations. The wider a young geologist has traveled, the more numerous the excursions in which he has taken part, the better will be his equipment. But no general work such as this can supply the place of systematic mapping. And the more exact the mapping is, the better the training. Very frequently the educational value of the mapping in detail of a small area is underestimated. Indeed, I hold that nothing else can take its place. Moreover, the only sure way to test a geologist is to require him to delineate upon a map and in structural sections the detail phenomena of the field. For my part I have more confidence in the

future of a young geologist who has mapped in detail twenty-five square miles, and has got out of the area much that is in it, than that of another who has done no detail work but has run over and written about thousands of square miles. Rarely can the general conclusions of a man who has not done systematic mapping be relied upon. In America there have been conspicuous cases of men calling themselves geologists who have never carefully mapped a square mile. Yet some of these by the undiscriminating have been regarded as leading geologists. And in one or two cases these men have gained a wide hearing. But the systems which they built up had little or no relation to the world; and they disappeared with the death of their authors. But a geologist must not only do systematic field work at the outset; he must continue to do such work through the years to a ripened age. Not infrequently a geologist, who in early life has done systematic field work, drops this work and continues writing geological philosophy; but this is a precarious course, which sooner or later makes of him what one of our members calls a "closet geologist." It is only by never-ending action and reaction between the complex phenomena of geology in the field and reflection as to the meaning of the phenomena that sure results can be obtained.

While one should spend a part of each year in the field, I suspect that many more discoveries of geological principles are made in the office or in the laboratory than in the field. The cow collects the grass in the meadow, and afterwards lies down to chew the cud and digest the food. So the geologist in the field, in the midst of innumerable facts, collects all he can. His notes are a record of his daily collections; and if a successful geologist, of his daily imperfect inferences and deductions. But during the eight or nine months of office and laboratory work he has full opportunity for reflection. He is then likely to see more of the common factors of the facts collected; is more likely to see deeper into the underlying principles which explain them.

While the work of each geologist should be based upon thorough field and office work, and thus have an inductive basis, one should not there stop, but should by deduction ever be looking

forward. No one ever held more firmly to fact as a basis for induction than Darwin; but also, no man has more successfully projected by deduction beyond his facts than Darwin. This in biology was a task of extraordinary difficulty. In geology one who has a firm grasp of the principles of physics and chemistry may be more daring. Their principles, if not more definite than the laws of biology, are at least better known and more simple. Therefore, one, after having observed the facts in a district and grasped the principles which explain them, may deduce what are likely to be the facts in the field and their relations in advance of observation. Or more concretely, after one gets the correct idea as to the meaning of the phenomena for a certain district, he often can tell in advance of observation what he will see; or can find what I call "geology made to order."

There is no better or more severe test of a theory than one's capacity to find geology made to order. If observation of the area where the facts are expected to be found in a certain way shows that nature does not obey the order, this is certain evidence that one or more factors in the problem have been omitted and that the theory is inadequate. In so far as the theory is adequate, the geology will be found as anticipated. The reason for this is the very great complexity and delicate adjustment of the phenomena of nature. To illustrate, if the many parts of some complex machine, such as a Hoe press, or a chronometer, were scattered far and wide, and then one should gather some of these parts, and try to fit them, he might find that a certain set fit perfectly. If this were so, he would know to a certainty that these parts are in the correct positions and relations, even if he did not know the relations of these parts to other parts or the purpose of the whole; for so complex and exact is the adjustment that there is but one way to put the parts together. Another set of parts might be found and these made to fit. But doubtless certain parts would not be found. These would be missing links necessary to make a perfect machine. In this situation, if the man had a genius for mechanical construction, and an insight into principles, he might be

able to understand the purpose of the whole, and finally to supply the parts which render the whole a useful machine. This he would be able to do just in proportion as he had mechanical insight.

So the geologist fits together his numerous diverse facts. If he finds a solution of his problem which gives accordance to all the numerous facts observed, he may be sure he is on the right track, even if he is incapable of seeing the full truth, for so delicate is the adjustment of facts that where they are numerous there is usually only one way to put them together. Just in proportion as the man has a working knowledge of the principles of physics and chemistry and biology, and the other cognate sciences will he be able to eliminate erroneous explanations, combine the facts into groups under true theories, and correctly infer how the different groups are to be adjusted, how the various facts which seem at first to have no definite relations are related.

Men with defective basal training and poor intellectual power will always fail when they try to put complex facts together under principles, and especially when they attempt to project by deduction beyond observed facts. But men who have a firm grasp of the principles of the sciences basal to geology, the capacity to correlate these principles and apply them to the facts of geology, will go beyond their observations and by deduction will reach conclusions with perfect confidence which are far in advance of observation. Indeed in this way only can the best geological work be done. After one has projected his deductions in advance of observations, he returns to the field with these new ideas, and then carries his observations farther than he was able to do before. The geologist whose ideas are not continually outrunning his observations will never go far in the science. He whose mind is behind his observations instead of in advance of them, will ever be mediocre. The minds of the leaders of geology are on the mountain heights before their feet have more than touched the foothills.

The conclusions deduced by a scientific genius may go so far in advance of observations that he who announces the conclusions may not be able to make observations which confirm

the theories during his lifetime. In such cases subsequent observations made through many years by others will find the phenomena confirming the principles. The truths announced by men of insight are often not accepted by slower men until this later observational work is done. Many cases could be cited illustrating these statements. Darwin, in 1860, knew that life had existed that would fill in the great gaps in the very imperfect paleontological record. Since 1860 all the greater gaps have been filled by discovered fossils. Mendeleeff, when he saw the law of the periodic arrangement of the elements, *knew* that elements exist which would fill the gaps; but it took many years of work by many men to find a part of them; and during the past few years a half dozen or more of the vacant places have been occupied. Each geologist, each scientist, now as in the past, is just as right as he should be. The scientific seers will ever go far in advance and guide others, even as did the spiritual seers of old.

The scope of these observations doubtless extends beyond geology. Much of what has been said is true of knowledge as a whole, not restricted to one subject. But I shall have accomplished my purpose if what I have said be true of geology; for if my conclusions be well founded, they furnish the basis upon which courses leading to degrees in professional geology should be laid out, and to methods of good geological work in the field and in the office.

THE EXAMINATION AND THE EXAMINEE IN ELEMENTARY SCIENCE.

BY JOHN WADDELL,

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The average examinee considers examinations as an ordeal which he must pass in order to obtain a certain certificate. He looks upon the examiner as a man whom he must try to convince of his knowledge of the subject, and if he can do this without excessive study, so much the better. No doubt, the examiner has largely himself to blame if the examinee can pass the examination

without a reasonable amount of study. The examination should not be of the kind that can be crammed for, but should require thoughtful application on the part of the student. It must not be of such a character that a candidate having accumulated a number of undigested facts without any knowledge of their relationships may be able to present a good appearance. If definitions are asked for, care should be taken to ascertain that the definitions mean something to the examinee as well as to the examiner. The words may be exact, the idea expressed may be perfectly correct, and yet the candidate may have no more conception of what is meant than if he had committed to memory a list of words taken from an unknown language. For instance, the statement of Avogadro's law, that equal volumes of different gases under the same conditions of temperature and pressure contain equal numbers of molecules, may be given correctly, and yet the candidate might be entirely at sea if asked what volume of hydrogen would contain five million million of molecules, provided that under the same conditions of temperature and pressure one litre of nitrogen contains a million million of molecules.

Not that I consider the memorizing of definitions useless. The strengthening of the memory has some value, but I think that storing the mind with gems of literature is preferable to accumulating a stock of definitions. Definitions, accurately and exactly learned, may doubtless be of use in later life when their meaning is understood, and in this respect the learning of a definition is better than the learning of a series of words in a dictionary or of a page in a table of logarithms. I refer to the learning of definitions without understanding their meaning. The learning of a definition, when the value of each clause and word is appreciated, is quite a different matter and is, in the highest degree, education.

The pupil beginning the study of science should realize from the very first the necessity of accuracy and exactness. He should learn that his knowledge, while necessarily limited, should be definite and distinct. A hazy idea of principles and facts is most unsatisfactory. The term *science* denotes *knowledge*, and knowledge should be exact and not of a general and indistinct kind. General knowledge has been wittily described as definite and dense

ignorance, and it must be admitted that many examination papers exhibit on the part of the examinees a great deal of general knowledge.

Accuracy of observation is one of the essentials of any scientific training, and any training is to that extent scientific in which accuracy of observation is insisted upon. If leaves are being examined, their shape should be accurately observed, the character of their margin, the texture, the surface, and other peculiarities, so that the pupil will realize that he *knows* something about the leaves he has studied. If flowers are examined, their peculiarities should be noted, and whatever object is looked at, the observation should be accurate so far as it goes. An examination paper can test such accuracy of observation. Taking an illustration from elementary chemistry instead of botany, such a question as the following may be asked, "What did you see when a piece of sodium was placed upon water?" The answer might involve the fact that sodium takes a globular form and moves about on the surface of the water; it might be that a yellow flame was seen; but that hydrogen was produced by the action of sodium on water, or that caustic soda was produced is not a thing visible in the experiment suggested. It is very important for the pupil to distinguish between what he sees and what he infers, and, still more important, to distinguish between what he sees and what *somebody else* infers. Unfortunately, most of our science students learn too much of what somebody else has inferred, usually without a knowledge of the facts from which the inference is drawn, and this inference, which we call a theory, is considered the fundamental fact and the things observed are supposed to hang upon it rather than it upon them. Such a theory is the atomic theory. Examinees in elementary chemistry, when asked to describe a chemical phenomenon, are all too apt to describe it in terms of atoms and molecules, and in such wise to show plainly that their knowledge is of the general kind mentioned above.

It is not uncommon to relegate memory to a very subordinate place in the study of science. We are told that what is required is that the pupil should understand principles, not remember facts. But the concrete is the best introduction to the abstract

and principles are best arrived at through facts, are best illustrated by facts, and are most definitely remembered in connection with facts. It is true that it is more important to train a child to investigate for himself than to give him the result of others' investigation, but the time is too short for him to investigate all he should know. It is in most sciences as it is in geography. The most complete and vivid knowledge of geography is to be got by travel, provided the traveler knows how to observe. But most people have to be content with a knowledge of other countries got at second hand. So in science; in many instances we must rest content with getting our facts second hand, and to get a clear view of the subject and to obtain a firm grasp of the principles, facts must be fixed in the mind. Hence, in an examination paper some questions involving an exercise of memory are not out of place. The examiner should be very careful in setting questions of this kind. The questions asked should not be out of the way ones. They should not in any sense be catch questions, they should be of the kind that any candidate in that grade of examination should know. For instance, in chemistry any pupil ought to learn how hydrogen is prepared or carbon dioxide, or hydrochloric acid, and the properties of these substances, and a question on matters similar to these is well suited to an elementary paper.

The case of carbon dioxide illustrates what I have said above about taking some facts in science second hand. It would not be easy for the pupil to perform an experiment to show that for a given amount of carbon, carbon dioxide contains twice as much oxygen as carbon monoxide; but he should know the fact. Unfortunately, when he does learn the fact, he does not realize that the fact has primarily been learned by experiment, but is liable to talk about atoms and molecules in such a way as to indicate that he considers carbon monoxide and dioxide as specially created by a kind Providence to illustrate the law of multiple proportions. Examinations have a very important function in stimulating the examinee to fix in his mind a number of facts. The student goes over and over his work with the view of making sure that he can tell a straightforward tale to the examiner, and in

doing so finds that the facts gain a definiteness in his own mind which they formerly did not possess.

An examination should not consist entirely of questions of fact. It should be such as to test the examinee's knowledge of underlying principles, and the relation that facts bear to each other. It would be well if some facts that the examinee is not likely to have met could be given and an explanation of them required, care being, of course, taken that the explanation depends upon principles that should be known.

Any little turn of a question that will put the matter in a different light from the ordinary is useful, and the examinee should try to get such a grasp of the fundamental ideas that he will not be caught unawares. There should not be too many questions of this character, for the examinee should not meet too much that is strange, but, on the other hand, the examinee should not have acquired so superficial knowledge of the subject as to be nonplussed by a change in form of question. There are not a few examinees in chemistry who could tell how carbon dioxide and chlorine are made, but would think they were asked something out of the way if requested to give the action of hydrochloric acid on marble and on manganese dioxide.

The science student should endeavor to cultivate accuracy of observation, exactness in the knowledge of facts, a clear insight into the relationship between kindred facts, and an appreciation of the principles involved; the examination should be of such a kind as to determine whether the candidate has made this endeavor and how far he has been successful, and should stimulate the examinee to strive in the best manner for the attainment of a thorough understanding of the work gone over, and for such a mental training as will be of permanent value in future life.—*The School Journal.*

LABORATORY WORK IN PHYSICAL GEOGRAPHY.

BY A. C. NORRIS,

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Much has already been said in this journal in regard to teaching this greatly abused subject. The aim of this article is to present the subject from a somewhat different standpoint. Ten or twelve years ago, when many of us were taking our high school course, we did little or no laboratory work; while today most high schools are doing better work than the smaller colleges did then. This is due to the fact that we have better textbooks, cheaper apparatus and chemicals, and better trained teachers. Physical geography, however, is still in the chaotic state that physics and chemistry were a dozen years ago. Who will come to the front and publish a laboratory guide in physical geography?

The question may be rightly asked, what can first or second year pupils in the high school do along the line of laboratory work which may help them to understand the subject better? The object of this article is to answer this question. The first subject usually treated in our textbooks is that of Elementary Astronomy. A few problems are: To find the latitude and longitude of the school house by means of the sun; to construct a sundial; to lay out the plan of the solar system; to learn the principal constellations; to study an eclipse, if possible.

The subject of the atmosphere offers an excellent opportunity for home and class room work. A few experiments are: Construction of a barometer, thermometer and hydroscope. (A thermometer, weather vane and rain gauge at home, in connection with the school barometer, offer material for a complete weather record, provided the weather vane has a speed indicator); study of atmospheric pressure by means of an air pump and accessories; the study of the different forms of precipitation by means of a

freezing mixture to form ice, ether to form dew, steam to form mist or fog, and wax to make artificial hailstones. Twice the writer has been successful in making a miniature snow storm, by letting cold air enter a moisture-laden room.

No teacher should attempt to teach physical geography without a good collection of rocks and minerals, and the knowledge to use them. If your school has not such a collection, don't draw your next month's salary until you have convinced either pupils or board that you *must* have them. Good collections may be purchased for from $4 to $10. With such a collection as a nucleus, you will have no trouble in getting pupils to bring in local specimens. Don't be content until every pupil knows at least a dozen rocks and minerals. If encouraged, most pupils will know fifty.

Mountain folding, faults, strata, longitudinal and transverse valleys may be illustrated by means of thin plates of paraffin or beeswax. Lava cones may be made of glucose poured on a glass plate, while coal ashes and sand make good materials for ash cones. A miniature volcano is easily made from sand. The top is to be made into a crater, and this filled with equal parts of sugar and potassium chlorate. When ready for an eruption, drop on the top several drops of sulphuric acid. If properly constructed, it will erupt from thirty to fifty seconds.

A few problems that may be shown in regard to rivers, lakes and springs are: Analysis of some medicinal water for soluble salts and gases, such as sulphates, chlorides, iron, lime and hydrogen sulphid. Analysis of some suspected well water for ammonia, chlorides and organic matter. The filling of lakes may be shown by allowing some dirty river water to settle. The action of geysers is illustrated by boiling a saturated solution of brine in a long glass tube. The "bumping" will cause quite violent eruptions.

Enough has been said along the line of class room work. What we need is some manual covering the ground more fully than has been attempted in this article. The enthusiastic teacher will teach much by means of trips to points of geologic interest near the school. Pupils enjoy these outings on Saturdays, the press makes a note of them, and the parents are encouraged and

influenced by them to take a keener interest in our school work. This subject of physical geography is a live one, needs only a little enthusiasm and tact to make it the most valuable of all the sciences. The writer would be pleased to hear from any one who has done real systematic work in this subject, and who has suggestions or criticisms to offer.

AN EXPERIMENTAL ILLUSTRATION OF OSMOTIC PRESSURE.

BY C. F. ADAMS.

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Doubtless many teachers of physics like myself have had much trouble in illustrating osmosis by the methods usually given in the textbooks and the following experiment may be of interest to them.

Acting upon a suggestion of Dr. L. Murbach, given in the November number of SCHOOL SCIENCE, page 300, I secured a large, sound carrot. In the axis of this by means of a carpenter's bit I bored a hole about 2.5 cm. in diameter and 10 cm. deep. I also peeled the carrot up to its crown. The hole was then nearly filled with sugar and water added to within a centimeter of the top. To close the hole a two-hole rubber stopper was used, in one hole of which was inserted a piece of barometer tubing about 2 m. long and having a bore of about 1.5 mm. After the stopper with the long tube was firmly driven into the top of the carrot, the other hole in the stopper was closed by a glass plug. It was then supported, by means of a clamp, on a ring stand in a beaker of water so that all but the top was immersed in the liquid. Two hours and a half after it was first set up the liquid had reached the top of the tube. At four o'clock in the afternoon the carrot was again filled and set up and the glass tube lengthened by con-

necting another glass tube to it by means of a piece of rubber tubing. The bore of the upper tube was larger than the lower one and hence the rate at which the liquid rose through it was much less than in the lower one. The top of the tube was 308 cm. above the water in the beaker. At 8 o'clock the next morning the tube was full and the current in it was still upward, while on the outside of it there was a trail of thick syrup, showing that it had run over during the night. The liquid forced up the tube was a thick syrup with a density possibly of 2 g. per c c., hence the pressure here shown is about twice as great as it would have been if pure water had been raised to the same height, but only a fraction of the total osmotic pressure such a solution of sugar is capable of producing.

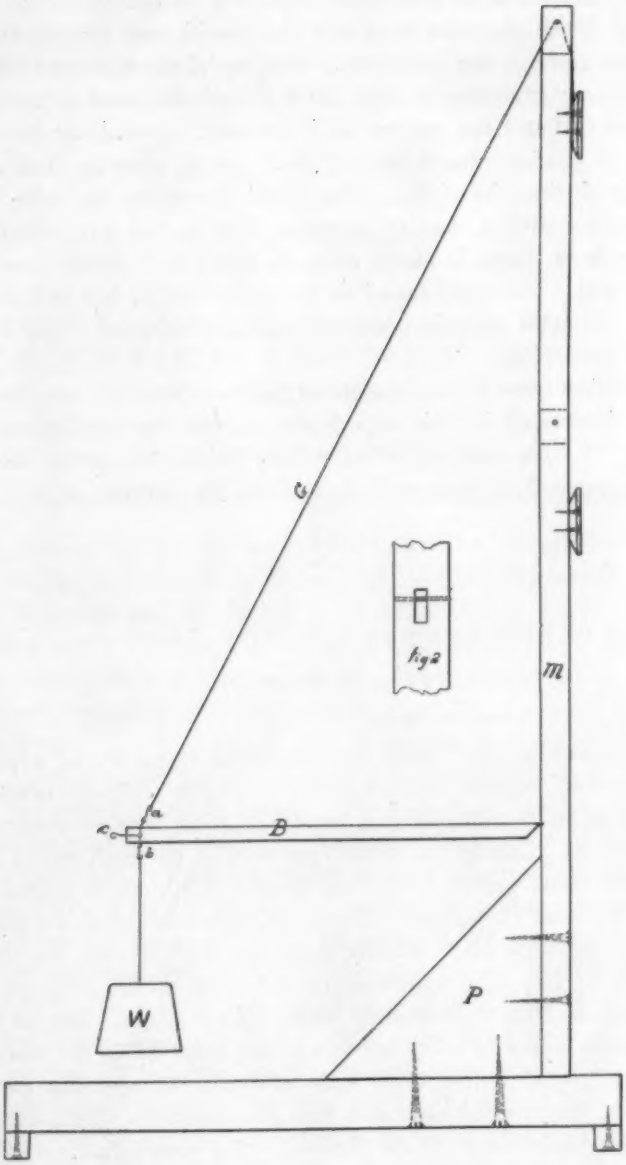
Perhaps some of the readers of SCHOOL SCIENCE may be sufficiently interested in this experiment to test its possibilities still further. I have tried other vegetables besides the carrot but none of them seemed to be so well adapted for the purpose as that.

AN EXPERIMENT IN RESOLUTION OF FORCES.

BY E. C. WOODRUFF.

Instructor in Physics, La Grange (Ill.) High School.

Composition and resolution of forces seems to be a part of physics that puzzles the majority of pupils. Their bewildered state of mind is probably due largely to their lack of constructive imagination. Among the other functions of the high school laboratory the development of a constructive imagination seems to be one of the most important. Hence the more intimately we can deal in the laboratory with difficult questions that involve this faculty the better. The usual experiments with three spring balances cover the questions in composition of forces satisfactorily. But so far no experiment seems to bring out the points involved in the resolution of a force. Of course every case of static composition can and should be interpreted also as a case in resolution. Still even this will leave something to be desired. An experiment where the question of resolution is the leading question would seem to be


C
fig 2
m
a
c
B
b
W
P

especially desirable. Such an experiment is the subject of this article. The experiment consists in investigating the stresses of extension and compression in a simple crane or a tie-bracket. The load constitutes a single known vertical force to be resolved into a compression along the boom and an extension along the tie-bar or whatever takes its place.

The problem is to be solved in three ways: (1) Trigonometrically and (2) graphically by measuring the necessary sides and angles of the triangle formed by the three forces, and (3) by substituting a dynamometer for the different members of the crane, one at a time, and taking the readings.

The crane is constructed as follows: A heavy base supports the mast *M*. The mast is 2x4 cm. in cross-section and 80 cm. high. It is firmly braced by the triangular piece *P*. The boom *B* is 30 cm. long and 1x2 cm. in section at the mast-end, tapering outward to 1^2 cm. The mast-end of the boom is beveled as shown and fits into very shallow notches in the mast. The outer end is furnished with three loops of strong flexible cord, taking the directions *a*, *b*, and *c*. *b* supports the weight *W* which may be a scale-pan and weights, *a* fastens to the guy rope *G*, and *c* furnishes means of attachment for a dynamometer. The notches in the mast are made 20 and 30 cm. from the base. 15 cm. above the upper notch a slot is cut through the mast as shown in Fig. 2, and a brad is driven across the slot to furnish a bearing for the guy-rope. 30 cm. farther up, at the top of the mast, is placed a similar bearing. On the back of the mast are fastened cleats to hold the free end of the guy-rope when necessary.

The experimental operations are as follows:

(1) The apparatus is set up as in the figure with a weight of perhaps one kilo, the guy-rope over the upper bearing, and the boom in the lower notch, adjusted so as to form a right angle with the mast. The sides of the force-triangle will then be 30 cm., 60 cm., and $\sqrt{60^2+30^2}$ cm., or if the right angle is not exact the sides may be measured.

(2) A dynamometer is attached at *c* and pulled horizontally until the boom starts to drop. The maximum reading equals the compression along the boom.

(3) The boom is replaced, the guy unfastened from the cleat,

the dynamometer fastened to a loop in the guy and pulled in, in the proper direction, until the boom is supported as at first. The reading is then the tension of the guy.

The three ways of obtaining the stresses in boom and guy should agree fairly well, success depending to a great degree on the operator. This makes the experiment all the more valuable pedagogically. In the case cited the stress of the boom and the load should have been related to each other as 1 is to 2. Now by using the proper combination of bearing and notch the 60 cm. of the first case becomes successively 45, 30, and 15 cm., and the strain on the guy increases very rapidly. By shaping the notches in the mast properly, cylindrical-shape, the boom may be used at other angles than right angles with the mast with profit.

Before this experiment was originated one normally bright pupil had some difficulty in believing that the strain on a brace or a guy could be greater than the load, *e. g.*, how the strain on a clothes-line might be enormous with a comparatively light load. His difficulty vanished when faced by empirical evidence. This experiment has to a considerable degree the power to direct a pupil's attention to the applications of the principle involved that he daily meets ordinarily with unseeing eyes, such as telegraph, telephone, and trolley lines, street lamps, clothes lines, steam derricks, shovels, dredges, and cranes in general.

A more elaborate form of guyed crane is also being used in the writer's laboratory. One where the boom has a bearing on the base board and is placed at any angle. The mast is loosely stepped near the boom's bearing and is guyed from behind. Any concurrent three of the half dozen members are investigated at a time, the others remaining constant. The apparatus is in fact a hoisting derrick, fitted with the proper pulleys, etc., and proves of much interest to the pupils. The experiment takes no longer than more conventional ones and teaches many things.

A SIMPLE METHOD OF MEASURING THE EARTH'S MAGNETIC FIELD.

BY HERMAN D. STEARNS.

Associate Professor of Physics, Leland Stanford University.

In this paper I shall indicate a method by which the better students in a high-school class many measure the horizontal component of the earth's magnetic field with sufficient accuracy to make it instructive, and which is so simple that they may understand every step in the process. I am not aware that it has been described before. I shall present the method in the form of a laboratory exercise.

Select two knitting needles nearly alike. Magnetize both so that the poles shall be very near the ends and determine the position of the poles as carefully as possible. Call one needle A and the other B. Let the pole strength of A be m, and let that of B be m'. Let the horizontal component of the earth's magnetic field be H.

FIRST POSITION.

Suspend A by a long fine silk thread so that it is free to move about its center in a horizontal plane. Allow it to come to rest indicating the direction of the magnetic meridian.

Turn A in the horizontal plane until it is perpendicular to the magnetic meridian. Hold it in this position by means of a very fine silk fiber about 10 cm. long, one end of the fiber being fastened by soft wax to one pole of A, the other end being fastened at the same height to a movable block of wood. Move the block until the fiber is perpendicular to the needle, as in Fig. 1.

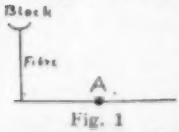


Fig. 1

The needle A is now at rest under the action of three forces, as shown in Fig. 2. The mechanical force F acting through the fiber on one pole of the needle is exactly balanced by the two magnetic forces acting on the poles of the needle, which are due to the horizontal component of the earth's magnetic field. If the poles are equally distant from the center of the needle we have

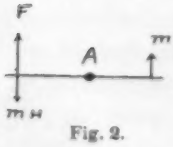


Fig. 2.

(1) $$F = 2\ m\ H$$

To measure F, slip a wire weighing about 10 milligrams over the fiber midway between the block and the needle and move the block nearer the needle until the position of the needle is the same as before the weight was added. The force F is now unchanged, and can be computed in dynes by a simple resolution of the forces shown in Fig. 3, if (a) and (b) are carefully measured.

Fig. 3.

SECOND POSITION.

Remove the needle A and suspend the neeedle B as A was suspended at first. Hold B in the same position as A in Fig. 1, but instead of a fiber use the repulsion between one pole of B and a like pole of A, as shown in Fig. 4.

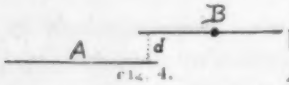
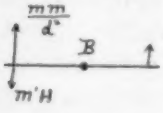


Fig. 4.

A may be supported on a block of wood. It should be parallel to B, and at the same height, and should be moved in the direction of its length until the adjacent poles of the two needles are opposite one another and produce the maximum repulsion. Call the distance between the poles (d) and measure it as accurately as possible in centimeters.



The needle B is now under the action of the forces indicated in Fig. 5, and the equation is:

$$\frac{mm'}{d^2} = 2\ m'\ H$$

or

(2) $$\frac{m}{d^2} = 2\ H$$

From equations (1) and (2) find the values of H and m and interpret the meaning of these values.

A study of Figs. 4 and 5 will show that equation (2) will not apply if (d) is too large. If (d) differs greatly from 4 cm. for needles about 22 cm. long, change the pole strength of A until a proper value is reached and repeat the experiment.

Metrology.*

THE RECENT METRIC BILL.

BY RUFUS P. WILLIAMS.

A consistent metricist is sure to take issue with some points of House of Representatives Bill 123, now before Congress. The bill is as follows:

Be it enacted, That on and after the first day of January, nineteen hundred and four, all the Departments of the Government of the United States, in the transaction of all business requiring the use of weight and measurement, except in completing the survey of public lands, shall employ and use only the weights and measures of the metric system; and on and after the first day of January, nineteen hundred and seven, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States.

Of the two separate parts, government usage and legal standard weights and measures, the former is the dominant issue. While any of the executive departments of the government have a legal right to use the metric system, and while several of them do use it, there will be no universal use by the departments until a compulsory law is enacted. This general feature of the bill is to be commended as a first step in metric reform. Three items in this proposed legislation, however, merit especial consideration. 1. The public land survey. 2. The date for government usage. 3. The legal standard clause.

1. The real necessity for making an exception of public land measurement is not apparent, but it leads one to conclude that surveying stands so far apart from other crafts requiring measurement that it should have special consideration. Such is not really the case. The chief opponents of the metric system have not been surveyors or civil engineers. These have more often been friendly to the reform. As far back as 1875 the Boston Society of Civil Engineers passed rosolutions favorable to the system, and the United States Coast and Geodetic Survey has used it for the best part of a hundred years, in fact from its foundation.

* Communications for the Department of Metrology should be sent to Rufus P. Williams, North Cambridge, Mass.

Judging from the character of the opposition among the various trades one would think that the naval department and the machine shops of the government should be excepted if anything is, when one takes into account the screw threads, the fittings of all adjustable parts, and the machinery used in making the same.

Aside from government works, machinists and mechanical engineers have been the greatest opponents of the system, for it is claimed that with them the readjustment would be more difficult and expensive than in other lines of work.

Or, if exceptions are to be made, has not the Customs department some claim for consideration, since all laws pertaining to customs duties are framed for yards, gallons, bushels, pounds, etc., and all these must be changed in case the department uses the metric system exclusively?

The Postal department, too, might well ask to be exempted and allowed to run for another hundred years on ounces and pounds. If any exception is to be made why not except all the departments and leave things as they are? We believe there is no need of excepting the public lands, or anything else. If the reform is to be beneficial, let it benefit all at the same time.

The reason for inserting the exception in the bill appears to be that in 1895-6, when the question was before the Committee, certain influential men, as the Director of the Geological Surveys, and the Commissioner of the Land Office, believing in the merits of the metric system in general but wishing to retain the old one in their particular field, made it appear that the "people of the United States have become so accustomed by long usage to think of all land measurements in terms of the English system of miles, rods, links, chains, acres, etc., that it will be practically impossible to persuade them to adopt the metric system for land measurements," etc., all of which might be said with equal cogency in reference to any other department. The influence of these men carried the day and secured the absurd exception, which has been continued in every subsequent bill.

The bill reads . . . "except in completing the survey of the public lands"—as though the survey were nearly finished. In truth we shall always be surveying so long as the government

continues to own lands, especially if Uncle Sam goes on—as he is likely to do—acquiring more and more real estate. The land department will then have the anomaly, after everybody else is using the metric system, of antiquated measures.

When France adopted the metric system she made no exception of land measurements. The very foundation of the system was in surveying. Germany, Sweden and other nations, in enacting general metric laws, did not make partial exceptions. At best the change has got to bring some temporary inconvenience to every sort of business. But this inconvenience will be far less than the opponents of the measure set forth. The longer the change to a better system is put off, the harder will it be to make it. Probably the best time for the change was in 1821 when Adams—who was a real believer in the merits of the system—made his report. Could he have looked ahead 50 years, our generation would have known no other system than the metric.

2. The Shafroth bill, introduced Jan. 10, 1900, made the date for government usage Jan. 1, 1901, and the legal standard clause Jan. 1, 1902. These dates have been successively set forward until they now stand respectively Jan. 1, 1904, and Jan. 1, 1907. If a metric bill requiring government usage can be passed, it is debatable how far ahead such compulsion ought to be placed for the best interests of all concerned. The probability of passing such a bill must necessarily be much influenced by the date. If placed 25 or 50 years from now there would likely be little or no opposition, but the object of such legislation would be lost to the present generation. A time limit sufficient to enable all departments to prepare for the change, to supply the new implements of measuring, to train the employees in their use, is all that seems necessary. A period of five years would seem to be ample and three might easily suffice. In the event of a longer time little or no thought would be given the subject until the time for actual use became nearer. In Germany some 3½ years elapsed between the enactment of the law and its compulsory use, with two years of permissive use intervening. During this interval everybody had become accustomed to the new measurements and when the time came for all to change, nobody was left to be compelled. Yet this was an instance in which not the government officials alone, but

the whole people, had to use the new system. Three or five years therefore seem a sufficient time for inaugurating a change in governmental departments, unless a longer interval is set for the express purpose of winning adherents to the cause.

3. The double dates of the bill—Jan. 1, 1904, for government usage, and Jan. 1, 1907, for making metric measures legal standard measures are, to say the least, incongruous. We are ready to endorse, for this part of the bill, the resolutions—which were not passed—of the Mechanical Engineers at their last meeting, that the bill was "simply absurd." If there is necessity for the last clause at all, then the two events should bear the same date. Consider what legal entanglements might arise with double dates. (1) Are all the departments of government—the public lands excepted—to be compelled by law to use weights and measures three years before they are made legal?

(2) Is this clause a confession that the weights and measures of the metric system are not now legal? The law of July 28, 1866, made them legal and they are the only ones that have been legalized except for coinage purposes. The United States courts in rendering any decision must by this law, in absence of any other legal standard, refer all other weights and measures to the metric.

(3) Are all other weights and measures to be illegal after Jan. 1, 1907? And, if so, are the public lands to be surveyed by illegal measures? This question of what is to take place Jan. 1, 1907, has given rise to more controversy than all the rest of the bill, and has placed in the hands of opponents of reform a powerful cudgel. The National Association of Manufacturers attacked it, claiming that it meant compulsory use for all the people in every line of business. The Society of Mechanical Engineers did the same. Although it was explained by Mr. Shafroth, the maker of the bill, that that was not its purpose, and although Attorney General Knox declared that if such was its intent it could not be enforced, and though editorials in leading newspapers tried to set the matter right, yet the effect on the rank and file of those who read it was that of force, and they resisted. We believe that this last clause of the bill lost the metric system many adherents and raised an opposition that would not have existed against the main proposition.

What then was the real purpose of this ambiguous clause?

Mr. Shafroth states that its object is "to require all proceedings in court and all judgments in court, whether United States or state courts, to be expressed in the weights and measures of the metric system. It does not invalidate contracts made even after that time in other weights and measures, but the pleadings filed in cases, when the same relate to quantities and lengths, must be expressed in the weights and measures of the metric system."

According to the author of the bill, then, there are two distinct reasons for the obnoxious clause—pleadings and judgments in the courts (1) of the United States, (2) of the various states. The most that can be said in its favor as regards the first is that it strengthens the legality, makes what is already legal more legal. As every state has its own laws and usages concerning weights and measures, there might not be a case in 50 years coming before the United States courts in which the principle would be involved. The one most likely to come up would seem to be the land survey, which by this same bill is exempted from the category of legality.

As regards the state courts where questions of measurement and weight are constantly to be settled, it seems very doubtful whether the words "of and in the United States" would be construed as setting aside all the laws concerning weights and measures in all the states of the Union.

The bill under discussion was introduced by Hon. John F. Shafroth, of Colorado, Dec. 2, 1901, and was reported April 21, 1902. It has not yet been assigned on the House calendar, and is likely to meet the fate of its predecessors, there being not the slightest chance of its reaching the Senate even were it to pass the House. The most that its ardent advocates have hoped is to get a show of hands and find how the members of the House stand on the question. In the English Parliament the opinion of every member is known, but Congress has had no such canvass and the public is in ignorance of its attitude on the metric question

The Committee on Coinage, Weights and Measures, secured the most valuable array of facts and opinions in favor of the metric system that has yet been published, and issued an excellent report.

The present bill having been dissected, it is in order to ask what are the elements of a bill likely to have least criticism? In matters of reform "one thing at a time" is a good rule. What is

needed is a bill that is not ambiguous, that holds to the one point of government usage, and one that every man who knows aught of the metric system can ask his Representative in Congress to vote for or against. How would this do?

Be it enacted, etc.:

That on and after the first day of January, 1908, all the departments of the government of the United States, in the transaction of all business requiring the use of weights and measurements, shall employ and use only the weights and measures of the metric system.

NOTE.

Action of Mechanical Engineers on the Metric System.—After a spirited debate for and against the metric system by members of the American Society of Mechanical Engineers at their 46th semi-annual meeting in New York, December 3-5, it was voted, 34 to 29, "that the society should form the component part of a commission or committee to prepare the arguments on both sides of the metric question." It was also voted that "a letter ballot should be taken to obtain the sense of the members, individually, on the question, first, of the policy of making the metric system obligatory on the governmental departments, and second, on the question of making that system more obligatory than it now is on the community serving the governmental departments." A resolution so worded as to commit the society to a definite opposition to the policy of the system was lost by a vote of 37 to 32. Previous to the meeting, F. A. Halsey, associate editor of the American Machinist, had prepared and issued in advance to members an elaborate document of 48 printed pages in violent opposition to the metric system, and Sidney A Reeve, of Worcester (Mass.) Polytechnic Institute, had sent to members a 16-page article on the merits of the duodecimal system. On the other hand, a friend of the metric system had issued to each of the 3,000 members a copy of the Textile World canvass, which showed a majority in favor of the adoption of the system, and a copy of a recent reprint from School Science, "Partial Use of the Decimal System Thirty-five Years After Legalization."

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

CHEMISTRY.

Solid Hydrogen Peroxide.—When 95 per cent hydrogen peroxide is exposed to a temperature of —23°, it becomes solid, and when a trace of this solid is introduced into more of the liquid peroxide reduced to a temperature of only about 9°, large, clear prisms of the solid separate out. By pouring off the mother liquor and crystallizing again, a 100 per cent peroxide is obtained. By this process of infection with a trace of a crystal, solutions containing only 80 per cent of the peroxide may be readily made to crystallize. The pure peroxide, when brought in contact with even a very small amount of platinum black or manganese dioxide powder, is decomposed with explosive violence. Magnesium and lead in powdered form burn with great brilliancy, sending off showers of sparks. Wool or a moist sponge are immediately set on fire by a few drops of the anhydrous peroxide. As a disinfectant, the pure peroxide promises much. It is an ideal antiseptic, as it does not introduce any foreign matter into a wound and decomposes only into oxygen and hydrogen. In a state of purity, the peroxide can be transported without danger.

Zeitschrift für angewandte Chemie XV., 26, p. 642. H. STAEDEL.

An Apparently Safe Way to Mix Hydrogen and Chlorine.—Second in importance to the direct synthesis of water as a demonstration experiment is the synthesis of hydrochloric acid. Such methods as the one where a bottle full of the proper mixture of gases is thrown from a window into the sunshine bring out but a few of the points that need to be demonstrated. For that matter, even the more elegant method given by Newth shows little more than that a hydrogen-chlorine mixture is exploded by light. No doubt the suggestions to be here given have been tried before. Still, there seems to be no record of the degree of success that may have been attained. Perhaps the success of the method as used last fall was accidental and perhaps the experiment is not safe. In any case it might be desirable to proceed with caution.

Two thick, wide mouthed bottles were filled, one with hydrogen by displacement of water, and the other with chlorine by displacement of air. They were placed mouth to mouth, but separated by glass plates and put in the sunshine, the hydrogen bottle on top. The plates were then removed. The yellow color of the chlorine gradually disappeared and the bottles became filled with dense hydrochloric acid fumes. The reaction was quiet and progressive, but not complete. After ten minutes the bottles were held, one at a time, mouth to a Bunsen burner. The

resulting explosions were harmless, but very violent, much more violent than the same quantity of an explosive mixture of hydrogen and oxygen would have produced. Six or eight points were thus demonstrated with a minimum amount of trouble, but with a rather severe nervous strain, especially on the first occasion. The chlorine was made from potassium chlorate and hydrochloric acid. Possibly pure chlorine might have been more or less violent.

E. C. Woodruff.

Making Pure Oxygen.—If oxygen is made in a metal retort, it is a good plan to put in a few cc. of water. The water will boil before oxygen comes off. As soon as the steam comes free from air, the delivery tube may be connected to the gasometer. The oxygen will then come whenever it is ready, without any further attention or trouble, and will generally be over 99 per cent pure. This is not only a good method of getting oxygen for eudiometer and other more or less quantitative work, but it is the best when preparing for other purposes, since it is easier to carry on than if steam is not used, and it avoids the waste which is inevitable where the gas is used to sweep air out of the retort.

W. F. White.

PHYSICS.

Electrolysis of a Salt.—Place in the bottom of U-tube about a tablespoonful of clean sand and fill the tube with a moderately strong solution of sodium sulphate previously prepared by dissolving the salt in water, adding a few drops of phenolphthalein, and then a very dilute solution of sodium hydroxide until the solution becomes the *faintest* pink. Support the tube on a ring-stand and thrust the terminals of a battery into its branches. Results will be obtained in a few moments with three cells of a bichromate battery of 1.1 volts each, connected in series.

Holland, Mich. M. E. Dick.

The Study of the Voltaic Cell may be well introduced by means of the following experiment: Strips of sheet zinc and copper are cut of a size about 2 to 3 mm. wide and 60 to 80 mm. long. Two slits are cut in the side of a cork deep enough to hold the strips firmly 8 to 10 mm. apart. A copper and a zinc strip are inserted in these slits, the cork being placed at about one-third of the length of the strips. The longer ends of the zinc strips are amalgamated by rubbing them with a drop of mercury after they have been moistened with dilute sulphuric acid Two such pieces of apparatus are floated in dilute sulphuric acid in a jar or tumbler, thus forming two open voltaic elements. If one of these

be closed by bending the top of the copper strip over so that it will come in contact with the zinc strip, hydrogen is evolved at the copper plate and in about a quarter of an hour the zinc plate is completely dissolved. The open cell, however, does not undergo any change. The experiment is especially valuable in that it shows very well the production of electrical energy at the expense of chemical energy.

Natur und Schule, I, p. 370. E. GRIMSEHL.

Battery for Strong Currents.—For those who have no storage battery and can not well afford the expense of often renewing large Edison Lalande cells, the best battery for strong, continued currents is the Bunsen. A large part of the trouble and expense of Bunsen cells as they are ordinarily used results from the necessity of providing and caring for the amalgamation of the zincs. If salt solution is used instead of sulphuric acid the zincs do not need amalgamation. Such a battery, with salt and nitric acid for the two liquids, is theoretically very much cheaper in proportion to the energy available than any other cell in common use. An odor of chlorine would be expected from such a combination, but there seems to be none whatever. There is a slight odor of nitrous fumes, and if this should prove objectionable, the battery can be removed to another room, or boxed in, or chromic acid may be used in place of the nitric.

W. T. WHITE.

GEOLOGY.

The Geological Society of America has just issued pages 377-474 of Volume 13, as a separate brochure under the title "Catalogue of Photographs belonging to the Geological Society of America." The collected photographs now number 1,418, after a careful revision and rejection of all such as do not show clearly some geological process or phenomenon. The list is arranged by states and miscellaneous, and a separate list is arranged according to subject, as Ant Hills, Bad Lands, Beach Deposits, etc. The catalogue contains photographs largely from negatives in the collection of the United States Geological Survey. After each title is given in parenthesis the negative number of the United States Survey, and prints and photographs may be ordered from the Survey at the following prices:

Size.			Mounted.	Unmounted.
11	by 14	inches	35 cents	30 cents
8	by 10	inches	25 cents	20 cents
6½	by 8½	inches	20 cents	15 cents
5	by 7	or 8 inches	15 cents	12 cents
4	by 5	inches	10 cents	8 cents

Lantern slides are furnished through the Survey at 50 cents each, or 45 cents if 100 or more are ordered. This makes available the large number of pictures collected by the United States Survey in the best form, for while the catalogue of the Geological Society does not contain all the pictures of the Survey, it contains practically all that are valuable as illustrating either geological, physiographical or geographical subjects. Pictures or slides should be ordered through the director of the United States Geological Survey.

The catalogue, if not otherwise available, may be purchased from the secretary of the Geological Society of America, Professor H. L. Fairchild, Rochester, N. Y.

E. C. C.

Book Reviews.

Alembic Club Reprints—No. 16. Papers on Etherification and on the Constitution of Salts. By Alexander W. Williamson (1850-1856.) 13x19 cm., 62 pages. The University of Chicago Press. 1902. 40 cents.

"The papers reprinted here form a group of great interest to the student of the historical progress of chemistry. They date from a period at which the development of synthetic organic chemistry was only beginning to occupy the attention of chemists to any considerable extent, and they deal with a number of questions which were matters of controversy at that period. The most important of these questions were undoubtedly those concerning the theory of etherification, and the true relationship of alcohol and ether to each other, and both to water. It is in regard to his elucidation of these questions in particular that the name of their distinguished author, as that of one of the pioneers in the foundation of modern organic chemistry, will always be ultimately connected with the history of chemistry."

While these papers are probably too difficult for secondary school students, yet chemistry teachers will profit by reading them and should see to it that this reprint is in their libraries. Note should be made of the reduced price (now 40 cents) of these reprints and that the American publisher is the University of Chicago Press.

C. E. L.

Lectures on the History of the Development of Chemistry Since the Time of Lavoisier. By A. LADENBURG. Translated from the Second German edition by LEONARD DOBBIN. (With additions and corrections by the author). 14x20 cm., xvi and 373 pages. The University of Chicago Press. 1902. $1.75.

The reviewer has already in a review of Mach's *Science of Mechanics* (Dec., 1902, number, page 362) called attention to the importance of historical study on the part of the teacher of science. While the present book is written in quite a different vein from that by Mach, yet what was said in the review of the latter book can well apply to this one also. It is a significant fact that this English translation appears about thirty years after the first German edition; this should not be interpreted as a tardy appreciation of the excellencies of the book, but should rather be a proof of the permanent value of the author's presentation of the subject.

The book in its English dress has been amplified by the addition of two lectures which brings it quite up-to-date. The translation seems to be very smooth and the mechanical execution of the book is commendable.

Every teacher of chemistry should have the book in his library; he will find it both instructive and inspiring reading.

C. E. L.

Nature Study for Grammar Grades. By WILBUR S. JACKMAN, A. B. 13x20.7 cm. 407 pages. The Macmillan Company, New York. $1.00 net.

Few books on nature study are of greater interest to the progressive grammar grade teacher than this one. Although it is primarily a child's text-book it will also be a valuable addition to any teacher's library.

The aim of the book, as the author states it, is to outline some of the problems within the child's comprehension which arise from a thoughtful study of nature, and to offer suggestions which may aid in their solution. Every topic is therefore resolved into queries under each of which are suggestive points for consideration. Thus the chapter on "Autumnal and Winter Habits of Animals and Plants" opens with the question: "In what way does the gradual lowering of temperature affect animals?" "Consider: *a*) the food supply; *b*) necessity for

bodily protection; *c*) chief conditions that give rise to migration; *d*) chief conditions which give rise to hibernation; *e*) chief conditions which enable animals to remain active in their usual haunts during the winter season, etc."

In general directions for field work, the making of apparatus, or the necessary observations precede the questions. Then follows number work involving the quantitative side of the work, directions for drawing and painting various phases of the specimens and occasionally the embodiment of results in a tabulated or an essay form. The teacher is supposed to assign a topic to his class and then give them time for individual investigation. After experimentation the child reports in a class period the results obtained.

It is hard to imagine the child investigating the topics of food, minerals, work and energy without the direction or oversight of the teacher. In many of our city schools the necessary amount of field work and the proper equipment would be serious problems for the grade teacher. In many cases the teacher with some ingenuity can substitute inexpensive, home-made apparatus, but accurate scales, retort stands, barometers, glass and rubber tubing are not easily obtained or satisfactorily dispensed with.

While the reviewer heartily approves of the book, yet portions of the topics of light, sound, landscapes and of germination seem too difficult for the child.

The method of work in this book is especially worthy of attention. It approaches much more nearly that of the investigator than does the older method of teaching nature study. It requires independent work, encourages unbiased results and is suggestive to both *child* and teacher. It describes many important experiments and outlines much exact, quantitative work within the child's power. The value of the chapters that deal with soil, distribution of seeds, heat, astronomy, meteorology, and spring studies can hardly be overestimated. There are also topics on proper ventilation, heating, foods and the relation of food to work.

GERTRUDE A. GILLMORE, Teacher of Nature Study, Washington Normal, Detroit, Mich.

Reports of Meetings.

THE NEW YORK PHYSICS CLUB.

The twentieth meeting of the New York Physics Club was held in Pratt Institute, Brooklyn, on December 13, 1902, with Mr. J. M. Jameson, President, in the chair. After an inspection of the laboratories, the meet-

ing was opened by Mr. E. D. Pierce, for the Current Events Committee, who made a report outlining a plan of work and appointing different members of the club to be responsible for items of interest in designated journals of professional and scientific character. It is thus hoped to keep track of current events in the scientific world.

Mr. L. V. Case for the Text Book Committee presented a careful review of three books: (1) The History of Mechanics, by Dr. Ernest Mach (Open Court Publishing Co., Chicago); (2) Elementary Electricity and Magnetism, by D. C. & J. P. Jackson (MacMillan & Co.), and (3) Mechanics, Molecular Physics and Heat, by Dr. Milliken of the University of Chicago. (Scott, Foresman & Co.)

Dr. E. R. Von Nardroff, of the Erasmus Hall High School, for the Apparatus Committee stated that the movement to add a second elective year in physics to the course of study in the high schools of Greater New York was gaining ground and that the matter was to be discussed at the coming meeting of the New York State Science Teachers' Association. He urged the necessity of keeping in mind and preparing a suitable list of experiments for such a course. Dr. Von Nardroff showed three pieces of apparatus adapted for such advanced experiments. The first was a calorimeter of large size with electrical connections, coil, thermometer and stirrer for finding the heat equivalent of one joulé. The second piece shown was an instrument made by Kohl of Bonn, consisting of a combined whirling table, friction cup for holding water, index arm for weight attachment and thermometer, the whole intended to furnish a comparatively simple method for determining the mechanical equivalent of heat. The third piece shown was a simple form of electric projective lantern with detachable parts to be put into the pupil's hands and which they were expected to learn to operate.

The club then assembled in the large lecture room of Pratt Institute and listened to an interesting and instructive illustrated lecture by Prof. R. W. Wood of Johns Hopkins University upon "The Instantaneous Photography of Invisible Objects." Prof. Wood said in part that objects might be invisible from three causes, *first*, because being in total darkness they neither received nor emitted rays to the eye. This class he did not further discuss. *Second*, objects may be invisible on account of their rapid motion. This class has been rendered visible by methods of instantaneous photography. Series of illustrations were presented showing how a cat dropped back downward, turned over and landed on her feet, the waves in the air made by a bullet in motion through the air; by a bullet as it crashed through a pane of glass; a drop of water falling into milk with the form of the return splash; a drop of mercury falling on a plate of glass; a charge of shot in the air. Prof. Wood showed a series of photographs taken by himself illustrating the form of a sound wave under different conditions, some of which were the following; when reflected from

a plane surface; from curved surfaces of different shapes; from two curved surfaces; from a row of steps; when refracted by a CO_2 lens; when diffracted by a grating. In illustrating the third class of invisible objects or those which emit rays which lie outside the limits of the visible spectrum, two photographs were shown, one taken by yellow light, the other by light waves wholly invisible to the eye. The latter picture was taken by placing over the lens of the camera a compound screen consisting of plates of colored glass which cut off the red and violet rays and of a gelatine film stained with nitroso-dimethyl-aniline, which cuts off the heat rays, but permits the ultra-violet rays to pass. This screen Prof. Wood discovered. When the nitroso-dimethyl-aniline is fused between glass plates placed at an angle with each other it may be used as a prism. It forms a spectrum rich in ultra-violet rays and much longer than that formed by a quartz prism. It cuts off the visible rays except a little red and violet. When the screen referred to is placed in front of the lantern provided with the arc light, a very small trace of green can be detected by the naked eye. That ultra-violet rays are present is proved by the fluorescence of a crystal of uranium nitrate.

Reported by R. H Cornish.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

ABSTRACT OF PROCEEDINGS OF PHYSICAL SCIENCE SECTION.

The programme of Section A (physics and chemistry) of the New York State Science Teachers' Association, at the last meeting, was devoted wholly to physics. It has been thought best to concentrate all effort on one subject and thus secure practical results rather than scatter and get merely a smattering. Two meetings of the section were held in one of the lecture rooms of the Syracuse University Medical College, and both sessions were well attended by high school and normal school teachers and by college professors. Quite a large number of academic principals, in attendance at their association meeting, patronized the section meeting.

The first session of the section was held at 4 p. m., Tuesday, December 30, 1902. Mr. E. R. von Nardroff, of Erasmus Hall High School, Brooklyn, gave a strong address on "A Second Year's Course in Physics for the High School," in which he showed the necessity for extending the good work begun by the association in its physics syllabus, and the impossibility of completion, in the fullest sense of the word, of secondary school physics by approved methods in one year. Wireless telegraphy, specific heat, the spectroscope and the deeper parts of physics

are best understood after a year's training in the more elementary work.

Mr. H. L. F. Morse of Troy, High School, Mr. L. V. Case of the Washington Irving High School, Tarrytown, and Mr. Charles N. Cobb of the Regents' Office led in the interesting and vigorous discussion which followed. That the course suggested was desirable was admitted by all, and, on motion, a committee was appointed to prepare a syllabus for a second year's course in physics, the committee to report at the meeting next December. Mr. E. R. von Nardroff of Erasmus Hall High School, Brooklyn, Mr. R. H. Kittredge of Schenectady High School, Mr. Frank Rollins of Bronx High School, New York, Mr. Charles N. Cobb of the Regents' Office, Albany, and Mr. O. C. Kenyon of Syracuse High School were appointed as such committee.

At the second session of the section, held at 9:30 the next morning, Mr. George M. Turner, of Masten Park High School, Buffalo, the secretary of the section, read a paper prepared by Mr. O. C. Kenyon, of the Syracuse High School, who was unable to be present by reason of injury, resulting from a fall in his new laboratory. The paper was on "The Physics Machine Shop in Secondary Schools: Its Value, Equipment and Management. How to Use It and Benefit a Class of Pupils in the Making and Repairing of Physical Apparatus." The paper was a very helpful and detailed outline of a course in manual training, to be taken in connection with science in secondary schools. Mr. L. V. Case of Tarrytown High School and Mr. William M. Bennett of Rochester High School added much to the subject from their own personal experience. Several creditable pieces of home-made apparatus were exhibited.

Reported by E R. WHITNEY, Chairman.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

ABSTRACT OF PROCEEDINGS OF THE BIOLOGICAL SECTION.

The first paper was on "The Value of Research Work in Botany," by Chairman J. E. Kirkwood, of Syracuse University. It outlined the uses of research in the preparation of a science teacher of the secondary schools and colleges. Among other aspects of the subject, it noted a tendency in some colleges to so increase the amount of research work required that the general preparation in botany was made inadequate to the teacher's needs. Three necessary qualities of a successful teacher were pointed out: (1) A teaching personality, (2) scholarship, and (3) proficiency in the arts of teaching. Of these, the teaching personality is an innate quality and can not be acquired; therefore is outside the in-

fluence of research work. It was held that it was hardly possible to gain a thorough scholarship by research in narrow lines as required for the doctorate. Hence, a thorough grounding in the subject should be attained before research is entered upon. But research should nevertheless, be considered a very important part of the teacher's training, on account of the habits of thought and work which such training inculcates.

In the discussion of the paper, Professor Gager, of Ithaca, took exceptions to the need of strictly research work in the preparation of the high school teacher. He agreed that the teacher should become familiar with research methods, but thought the knowledge obtained was not often of practical value in the profession. He was, therefore, in favor of acquiring the methods by investigating subjects of direct aid in science teaching, which, though not new to science, were new to the teacher.

Others agreed with the paper that there could be no substitute, in the teacher's preparation, for genuine research, for the following reasons: Original contributions to the knowledge of a subject increase the student's permanent interest in the subject and inspire respect for him as a teacher. He becomes fitted to weigh the contributions of others and to understand through what stages the science has been developed.

On the second day of the session, Mr. M. Smith Thomas, of Le Roy, took up the subject of "Experimental Physiology in the High School." He particularly treated of laboratory methods which he found practical.

Discussion of the paper brought out quite varied opinions as to the relation of physiology, both theoretical and experimental, to the laboratory course. It was pointed out that an experimental course in pure physiology is entirely too difficult for high school pupils. Indeed, it is sometimes found a stumbling block to college students with two or three years' of previous laboratory experience.

The removal of physiology from the high school to the grades was advocated on the ground that five or six years' of physiology study in the grades give opportunity for as much of the science as is not too advanced for the high school and prevents the distaste for more of the subject, which the pupil often feels on taking it up in the high school.

It was the opinion of the speaker that simple dissecting, microscopic work, including the mounting of slides from material already prepared, experiments illustrating the action of digestive ferments and the like were not too advanced for the seventh and eighth grades.

The more general view seemed to be that experimental physiology, even in the high school, should consist, to a considerable degree, of observational work and demonstration by the teacher, assisted by pupils.

Mr. C. N. Cobb, of the Regents' Office, thought that too little emphasis is laid on laboratory work in physiology by the state, owing, perhaps, to the traditional methods clustering about physiology teaching, the difficulty of providing suitable experiments, and the relegating of physiology teaching to other than science teachers.

Owing to the diversity of view as to the best laboratory course for high school physiology, it was voted that a committee be appointed to formulate, for the association and teachers of the state a laboratory course suitable for high schools. Mr. Cobb, Miss Katherine S. Wetmore of Rochester, Prof. A. D. Morrill of Hamilton College, Mr. J. S. Kingsley of Newark Valley, and Mr. Thomas of LeRoy were appointed by the chairman.

Reported by E. G. CONGDON, Secretary of the Section.

Correspondence.

EDITOR SCHOOL SCIENCE:

In the article on "What Chemistry Shall Be Taught in the High School and How It Shall Be Most Effectively Taught," in the February number of SCHOOL SCIENCE, the writer says some excellent things about chemistry teaching. But it seems to me that he goes too far in his discouragement of attempts to teach chemistry with unsatisfactory equipment. Many a school with very fair facilities today would still be without a laboratory if a beginning had not been made in a small way. One of the best things that several of our newer text books have done for chemistry teaching is the description of more simple methods of performing the essential experiments. Splendid work can be done in chemistry with a class of sixteen pupils in a room furnished with tables, some shelves and a sink. My first class went through a very fair laboratory course in a room with no sink. No elaborate pieces of apparatus are necessary, except some balances on which weighings to centigrams can be made. While ventilating hoods are very important, if the room has good ventilation, all of a good high school course can be given without them, and that, too, without living half the time in a poisoned atmosphere, as we are at present demonstrating in our high school, where we enroll about one hundred pupils in chemistry. We have no ventilating hoods and our laboratory has been unpleasant from bad odors but once or twice this school year.

Fine equipment is desirable, but don't let us discourage the teachers in small schools from making the best of what they have, and trying for more.

HARRY CLIFFORD DOANE.

Central High School, Grand Rapids, Mich.

This number completes the second year of the existence of **SCHOOL SCIENCE.** The reception accorded two years ago to the magazine was most encouraging, and the continued and growing interest taken ever since has been most gratifying. The prosperity of a journal devoted to the interests of science teaching is a good criterion of the excellence of that teaching and of the character of the teachers.

SCHOOL SCIENCE can best thank its supporters by rendering itself more worthy. A number of interesting features for the third volume has been arranged for. The **MATHEMATICAL SUPPLEMENT** will certainly prove an invaluable aid to all science teachers. The **REPORTS OF MEETINGS** will be more prompt and more detailed. The other Special Features will be in every possible way improved.

SCHOOL SCIENCE hopes to double its sphere of influence during the next year, and earnestly bespeaks the active co-operation of every one who has the interests of good science teaching at heart.

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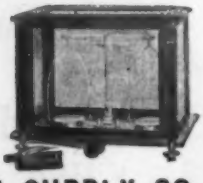

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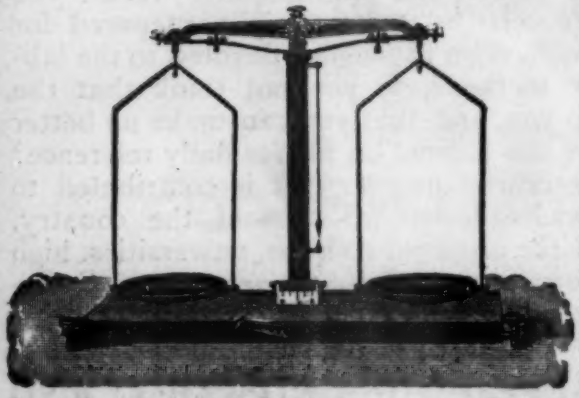

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